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JOURNAL
OF
THE ENGINEERING SOCIETY
OF
THE LEMIGH UNIVERSITY.

ISSUED QUARTERLY.

JUNE, 1887.

JOURNAL OF THE ENGINEERING SOCIETY.

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ABSTRACT OF PROCEEDINGS.

Thursday, April 28, 1887.—President LaDoo presiding, and the roll showing an attendance of eleven. The Treasurer reported a balance in the Treasury of \$56.79. Mr. Hittell moved that the Society present the Bethlehem Engineering Society with a full set, bound, of the JOURNAL. Carried. Mr. Phillips, '87, read a paper on the "Flow of Liquids in Short Pipes," and Mr. Cunningham one on "Railroad Topography."

Thursday, May 12.—The President in the chair, and eleven members present. The following officers for the ensuing year were elected:

Mr. Geo. Davis, '88, *President*.

Mr. H. H. McClintic, '88, *Vice-President*.

Mr. C. J. Parker, '88, *Secretary*.

Mr. L. R. Zollinger, '88, *Treasurer and Business Manager of JOURNAL*.

Mr. A. T. Bruegel, '88, *Librarian*.

Mr. C. C. Jones, '87, }
Mr. J. B. Glover, '88, } *Editors of the JOURNAL.*

Mr. Pettinos, '87, read a paper on the "Fireless Steam Engine."

Thursday, May 26.—The President in the chair. Twelve members were present. Mr. Bonnot made his official report as Librarian. Mr. Richards, '88, read a paper by Prof. Merriman

on his "Equation of the Curve of L U ." Mr. Palmer, '88, presented a paper on the "Method of Constructing Tall Chimneys without an Exterior Scaffolding." The Secretary presented a report on the recent visit of the Senior Civil Engineers to Wilkes-Barre, Pa., with a description of the Separate System of Sewerage in use at that place. President LaDoo rendered a very interesting report in his official capacity, in retiring from the chair. This was the last meeting of the year.

MASON D. PRATT, *Secretary*.

TRIP TO NEW YORK AND STAMFORD.

On February 11, at 8.20 A. M., the fifth year and senior miners and senior mechanicals, numbering twenty-three, left for New York City. At 1 P. M. we met Mr. Breckenridge at the Post Office and then proceeded to Wall Street to inspect several elevators.

Elevators are generally classed according to the motive power employed.

Hand.—When the power is applied by pulling a rope running the length of the hoist-way, which passes over a rope-wheel attached to a machine overhead.

Belt.—When the power is applied by a belt from a line of shafting which transmits the power.

Steam.—When the power is derived from a steam engine attached directly to the machine.

Hydraulic.—When the power is applied through a hydraulic engine operated by water obtained under pressure.

Hand elevators are used mostly for freight purposes with light loads, while belt, steam and hydraulic machines are equally applicable for either passenger or freight, the choice being a question of economy. The speed of either belt, steam or hydraulic machines can be adjusted to run from 50 to 300 feet per minute, or even faster if desired.

We first visited L. Hammersly & Co.'s Building, 38 Wall Street. In this establishment is used a horizontal hydraulic elevator, with Hynkle's patent pressure tank, built by the Wittier Machine Co. The tank and pump are on the same floor, which

does away with a storage tank on the roof, from which there is some danger of flooding the building. By this system a higher pressure can be produced. The apparatus consists of a discharge tank, steam pump and pressure tank. The water exhausted from the elevator is forced into the discharge tank, then it is forced into the pressure tank ready to be used again. The pressure tank, which maintains a constant pressure, serves the purpose of an air-chamber. The pump is arranged to start automatically when the pressure is reduced by the starting of the elevator, and stop automatically when the pressure is again reached. Any number of machines can be worked from the same pressure tank. The piston stroke is six feet and ten inches, and elevator lift is ten times the piston stroke.

At the Manhattan Company and Merchant National Bank Building, No. 40 Wall Street, there are four elevators and four tanks. Three of the tanks are in the basement and the fourth one on top of the building. The tank on top of the building, from which water is drawn to run the elevators, holds about 7500 gallons of water, or about one-third as much as either of the others. There are six pipes running from the basement to the top of the building, across which I beams are placed for the tank to rest upon. These pipes also serve to supply water to the tank on the roof, as discharge pipes and as guides for the elevators. This plant is very expensive and is seldom used. The friction through the long pipes must be overcome, and this requires a larger pump than when the tank is placed in the basement. The water discharged from the cylinders is restored to the tanks in the basement and used again. They carry about two pounds of back pressure in order to heat the building by exhaust steam. These elevators were built by Crane Brothers Manufacturing Co.

At the Orient Building, 41 and 43 Wall Street, is used a double screw steam hoisting machine for running two elevators. This is of the belt type, and was built by the Wittier Machine Co. This hoisting machine is arranged with two worms on the driving shaft, which work with two gears that mesh together. One worm and its gear are right hand and the other left. The gears mesh together as well as with the worms. The driving shaft is provided with an automatic strap brake to render the changes of motion prompt and to hold the load firmly when at rest. The engine is double, upright, and reversible and has an 8" by 10" cylinder.

The reversal is accomplished by means of an auxiliary balanced slide valve, situated between the two steam chests and operated by the shifting rope. This engine makes 250 revolutions per minute and carries eighty pounds of steam.

The Eagle Building, 71 Wall Street. The elevator is run directly from the engine, which has a 5" by 9" cylinder, and a thirty horse-power boiler. The exhaust steam is run through superheaters to heat the building. It takes as much coal to heat the building at night as it does to run the elevator and heat the building during the day. The rope used in all these elevators is made of wire and its diameter is very small in comparison with that of the drum.

We then visited R. Dudgeon's establishment, manufacturer of hydraulic jacks and tube expanders. The large cylinders for the jacks are made from solid pieces of forged steel, which are imported from England, and bored out, but those up to thirty tons are made from steel pipes. The mixture of liquids for jacks consists of one-third alcohol and two-thirds water. All the jacks are tested before leaving the shops. We then left Mr. Breckenridge with orders to meet him at the depot next morning.

On Saturday morning at eight o'clock we left New York City for Stamford, Conn., to visit the works of the Yale & Towne Manufacturing Company. This was the most interesting visit of all. We were first shown through the testing department.

Emery's Scale and Testing Machine.—In these machines thin strips of metal firmly secured at both ends are used in place of the knife-edge commonly employed in weighing and testing machines. The hydraulic support consists of a base in which is a circular chamber about $\frac{1\frac{1}{2}}{1000}$ inch in depth, which is filled with a liquid on which sits a pressure column. The liquid contained in the chamber communicates through a small pipe about $\frac{5}{100}$ or $\frac{6}{100}$ inch in diameter to a small sealed pressure chamber within the weighing mechanism. And any pressure brought upon the pressure column will be transmitted to the fluid enclosed beneath it, and this pressure will be connected through the small connecting pipe to weighing mechanism. Primary and secondary diaphragms are used so that by using smaller diaphragms the pressure may be reduced to any desired extent, the amount of reduction depending upon the ratio of the area of the primary and secondary diaphragms. The testing machine consists of two parts. The first is the machinery for putting the strains upon the specimens,

which consist of two screws carrying a straining beam to which a hydraulic cylinder is attached. These screws are attached to a frame in which a pair of beams is placed to furnish abutments for resisting the power. Whether the strain is tensile or compressive it will compress the liquid in the hydraulic support, and this pressure will be communicated to the weighing apparatus, or the second part of the machine, which consists of a system of levers and a scale beam, and a pressure column with its diaphragms to which pressure exerted in testing machine is transferred. The motion of the load is very small and the pointer comes to rest very quickly without vibrating a long time about the zero point. The diaphragm in a 50-ton testing machine has a total motion of $\frac{1}{400000}$ inch.

For one pound the change of motion is $\frac{1}{400000000}$ inch. The whole range of the diaphragm is $\frac{1}{1000000}$ inch. The indicating arm moves $\frac{1}{100}$ inch for each pound. The weighing machine is very sensitive. With 70000 pounds on the machine, the indicator showed the addition of a piece of waste.

In this establishment is used a traveling crane which is run by cotton rope running 5000 feet per minute. All the motions are effected by power derived from a fixed source, and are easily controlled by a single operator located on a platform moving with the crane. A special feature of the windlasses manufactured by this company is

The Safety Crab.—The load is always self-sustained by the automatic action of the safety brake so that the handles may be let go and the load will not run down. To lower the load the handles must be turned backwards. There is a pinion which turns loosely on the shaft, and when the load tends to pull the drum backwards it turns this pinion, jamming it against an inclined clutch, which throws it against the brake cylinder and makes the whole thing one rigid piece, and then this piece is prevented from turning by the pawl.

The chain making was very interesting. The men work by the day, consequently they work very rapidly, each man making from 40 to 45 feet per day. The chains are all tested in a machine before leaving the works. The extreme pull of the machine is about ten tons. Nine links are put in the machine and pulled to the proper pitch by trial, and then all the chain of this size is pulled to the same length.

We returned to New York City at 2 P. M., and went to Brook-

lyn to examine the Worthington pumping engines and hydraulic machinery. A pumping engine is run continually for the benefit of visitors. This engine is of the latest design. On this engine there is an arrangement to take the place of a fly-wheel in an ordinary engine. It consists of an accumulator about 18" in diameter and has an air-tight piston in it which is guided by a rod running through the top. The space above the piston is filled with air. On the end of the piston rod of the engine are connected two plungers which work into two chambers about 6" in diameter. These chambers contain water and vibrate on tubular trunnions which are connected with the lower part of the accumulator. Now, at beginning of stroke, when the engine is capable of storing up energy, the chambers are full of water and this water is pressed through the trunnions to the accumulator by the plungers, thereby compressing the air in upper part until the plungers pass their vertical position, at which position they begin to withdraw from the chamber, and the compressed air assists the piston to the end of stroke.

In all the establishments we were furnished with two or three men to explain the points of interest to us. Our time being limited, we were rushed through the establishments pretty rapidly, but the trip proved to be very interesting and profitable to us all.

J. M. HOWARD.

THE FLOW OF WATER IN SHORT TUBES.

It has been observed by hydraulicians that certain forms of orifices give discharges greatly in excess of the theoretical flow, under the existing conditions of head and section of orifice.

In other words more liquid is carried through the orifice than the conditions of pressure and the laws of flow would lead us to expect.

A consideration of all the forces acting upon the column of water is necessary in order to find an explanation of this seeming paradox.

The atmosphere, it is known, presses equally in all directions with a force of about fifteen pounds per square inch, equivalent to a head of thirty-four feet of water.

Any force which would tend to the production of a vacuum between any section of the orifice and a following section would

immediately increase the flow of water owing to the unbalanced pressure of the atmosphere acting on the free surface of the body of the liquid.

Let a section of the orifice be represented by Fig. 1, and suppose it has the form of the *vena-contracta* and $a - b$ is the minimum section.

The velocity at $a - b$, due to head h , has been found by many experiments to be $V = .97 \sqrt{2gh}$.

Let the area of a section near the extremity of the orifice as $e - f$ equal A' , and the area of a section at $a - b$ equal A . Suppose the stream unbroken at $e - f$, thus the mean velocity at $a - b$ and $e - f$ are as

$$V : V' = A' : A, \text{ or } V' = V \frac{A}{A'} = .97 \sqrt{2gh} \frac{A}{A'}.$$

The kinetic energy lost by the column of water per second due to the decrease of velocity equals

$$\frac{m}{2} (V^2 - V'^2) = \frac{AVg\rho}{2g} (V^2 - V'^2) = L.$$

Suppose a force P , at $a - b$, pulling continually on the molecules of the stream of water in the direction of the reservoir sufficiently to perform L units of work per second on $AVg\rho$ pounds. Now if P is the height represented by the above loss of kinetic energy, we have

$$\frac{L}{AVg\rho} = P = \frac{AVg\rho (V^2 - V'^2)}{AVg\rho} = \frac{1}{2g} (V^2 - V'^2).$$

Suppose $V' = 0$, or that the section of the orifice is so greatly enlarged that the velocity of the stream is 0, then $P = \frac{V^2}{2g}$, or the resistance P , is equal to the pressure of a column of water whose height is h .

Substituting for V' its value, $V \frac{A}{A'}$, in the above formula,

$$\begin{aligned} P &= \frac{1}{2g} \left[V^2 - V^2 \left(\frac{A}{A'} \right)^2 \right] = \frac{1}{2g} \left[2gh - 2gh \left(\frac{A}{A'} \right)^2 \right] \\ &= h - h \frac{A^2}{A'^2}. \end{aligned}$$

P can not exceed 34 feet, since if a greater force than that represented by the pressure of 34 feet of water is exerted between the sections of the orifice, a vacuum will be formed.



It would seem from the preceding that the stream of water coming through the orifice at the beginning of the flow would tend to cause a vacuum and thus increase the flow; and that in turn this increased flow would further act in the same way until the maximum possible increase of head due to the atmosphere, *viz.*: 34 feet would act. If this were true the rate of flow for any divergent orifice would be determined by increasing the actual head at once by 34 feet, and computing the velocity by formula $V = .97 \sqrt{2g(h + 34)}$. For a value of h equal to 34 feet, this would give a coefficient of flow 1.37 times the theoretical flow, and this coefficient would increase until it became infinity when $h = 0$.

By experiment it is known that the maximum coefficient of flow is about 1.5 times the theoretical value and this coefficient is for heads less than 20 feet, hence a further explanation must be sought.

The kinetic energy in a stream of uniform velocity is less than that in a stream having the same mean velocity but not uniform.

For, let a given stream have a uniform velocity of a feet per second, and let one linear foot of stream equal one unit of mass;

then $k = \frac{a^3}{2}$ is the energy developed per second.

Now, suppose one-half of the stream has a velocity $= \frac{2}{3}a$; and one-half a velocity of $\frac{4}{3}a$, then the mean velocity in this case is the same; but the kinetic energy,

$$k' = \frac{a}{6} \times \frac{4a^2}{9} + \frac{a}{3} \times \frac{16a^2}{9} = \frac{36}{54}a^3, \quad \text{or} \quad k' > k.$$

The stream of water flowing through the orifice, shown in figure 1, is obstructed by friction against the sides; in addition, the stream, after passing the minimum section, tends to flow straight forward with a uniform velocity; owing, however, to molecular attraction the stream does not separate from the sides of the orifice as the section enlarges, but it preserves a solid front. The particles of water near the center of the stream lose a portion of their velocity which is given to the side particles. Thus, in the enlarged section, the velocity of the stream is not uniform, but is a maximum in the center and a minimum at the bounding surface. It is shown above that the kinetic energy of this varying stream is much greater than if it were uniform.

Therefore, the tendency to produce a vacuum is not correctly represented by the formula, $P = h - h \frac{A^2}{A'^2}$; but a coefficient $c < 1$ should be introduced depending on the uniformity of the velocity in the enlarged section; and the formula becomes $P = c \left(h - h \frac{A^2}{A'^2} \right)$.

From the foregoing it appears that the increase of the coefficient of flow depends upon a variety of circumstances: 1. It is limited by the external air pressure. 2. It is affected by the friction upon the walls of the pipe. 3. It varies with the change in the section of the stream. 4. It depends upon the uniformity of the velocity of the water at the maximum section. 5. It is affected also by the resistance due to any sudden angles in the tube or at its entrance.

Experiment shows that a maximum value of this coefficient, nearly 1.5, is given when a compound tube with an angular divergent of $5^{\circ}06'$ is used.

This principle of the liberation of kinetic energy when the mean velocity of a steam is varied by a change of section has continual application in the action of the locomotive blast pipe, also in the steam-jet pump, and in the sand pumps used for excavating foundations.

R. H. PHILLIPS.

TOPOGRAPHICAL WORK ON A RAILROAD SURVEY.

A full party, and one best prepared for preliminary and location work for a proposed line of railroad, is made up of two parts; the transit party, which includes the levelman and rodman, and the topography party. The latter should consist of three men: The topographer, who has charge of the party, a levelman and a rodman.

The Locke level is used, set on a staff of such length that the horizontal wire is exactly five feet above its foot. The rod is made of some light wood, ten feet long, about two inches wide and half an inch thick. It is divided into feet and tenths, starting in the middle and numbered up and down. The figures should be marked very distinctly so the levelman can see them without difficulty. Should the rod get broken when in the woods and far

away from a carpenter shop, a very good one for temporary use can be made by cutting a pole of convenient diameter and the right length, and peeling the bark from the alternate feet; the tenths are guessed at when reading.

The topographer puts his work on sheets of white paper, 14 by 16 inches, which come specially for the purpose. His outfit consists of two drawing boards about 16 by 18 inches; one is to carry in the field and the other is to keep his partly finished and completed sheets in, at the camp or wherever the stopping place may be.

These boards are made hollow, having a space of about half an inch in depth, closed on three sides, the fourth opening by a leather flap or other convenient devise. In this are carried the sheets, a couple of triangles, a flat scale and a small protractor.

When at work one end of the board rests against the body, and the other is supported by a strap which passes around the neck, and is of such length that the board is in a convenient position for drawing on while standing, as all the work has to be done in this position. The sheet is fastened to the board by thumb tacks, and should be so placed, when possible, that the line runs toward the body and not from it.

He also carries a medium-sized compass, for taking the bearings of property lines, roads and houses; also for running auxiliary lines. These are run whenever he thinks it necessary, in order to show up the country to the best advantage. The protractor and triangle are carried so as to plot them in the field. The rest of the drawing is freehand.

The levelman carries a topographical book in which he records the contours, property and other lines, houses, roads and streams. So in case the sheets should be lost or destroyed the record would still be at hand. He should copy in it a table of natural tangents and cotangents for all degrees from 0 to 45. He also carries a clinometer, or preferably a slope board. The rodman is provided with a tape measure.

The method of work is as follows:

Suppose a preliminary line is to be run, followed by a location. The transit party is always a day or more ahead of the topography party, and sometimes when the country is rough they get a good many days ahead.

When the transitman comes in at night, he plots the day's work on the sheets, as near the middle of the sheet as possible, the preliminary line being usually plotted in red. He then hands

it over or sends it back to the topographer, who marks off the stations on it, and writes in small figures opposite each station, its elevation, taken from the level book. The elevations of all the plusses are written along the edge of the sheet, so as not to interfere with the contour, but be convenient for reference. A note should also be made on the sheet of everything of interest noted on the level book, such as names of streams, roads, etc., as it is often very useful in the field, especially if the levelman is familiar with the country and the topographer is not. The levelman also records in his book the elevations of the stations, both to save time in the field and as a check on the work. He keeps notes in the same way as the transitman, working from the bottom of the page upwards.

The most convenient scale and that commonly used is 400 feet to the inch. Five feet contours are almost always taken for railroad work, though sometimes ten feet are used. They are taken at right angles to the line, unless some other direction will show up the ground better, or on account of brush or other obstruction it cannot be done.

When ready to begin work the elevation of the station is seen from the sheet or note book; the levelman places his staff where he thinks the rodman held his rod, and sends *his* rodman out to one side, lining him in by sighting ahead on the line along one edge of his note book, then, keeping the book in the same position, turning his head and sighting along the edge at right angles to the first, fixing on a distant object in the line of sight to guide himself by. A first-rate right angle can be turned from the line in this way, and no time lost in doing it.

Suppose the elevation of the station to be 1463.4 feet, then as the level is five feet above the ground, we see that to find the 1460 contour the rod must be taken out on the lower side until 3.4 feet is read above the zero mark at the middle. The levelman then paces the distance out to where the rod was held, records it over the contour, and calls it out to the topographer, who lays the distance off from the line on his sheet. Where extreme accuracy is required the distances are measured with the tape, but this is only necessary in special places. After a little practice pacing can be done pretty accurately. When the slope is very steep the measurements should be made with the rod. The rodman goes on out, and to get the 55 contour the top of the rod is read. This distance is paced, recorded and laid off as before, the

whole distance from the line being written each time. This is continued as far as thought necessary. On the upper side of the station, to find the 1465 contour 1.6 must be read on the rod and this time below the zero. The convenience of having the rod marked zero in the middle and reading both ways, is thus seen, as otherwise for the first reading on each side of the station, the right quantity would have to be added to or subtracted from five. To find the 70 contour the bottom of the rod is read.

When as far out from the line as it is thought necessary the work should be specially accurate, a long slope may be taken with the slope-board, and the contour can then be calculated from the table of tangents and cotangents.

The left hand page of the note book is kept as follows :

STA.	ELEV.	CONTOURS													
		Center							line.						
13	1463.4	$\frac{50}{200}$	$\frac{140}{80}$	$\frac{88}{75}$	$\frac{57}{70}$	$\frac{18}{65}$	$\frac{23}{60}$	$\frac{62}{55}$	$\frac{95}{50}$	$\frac{128}{45}$	$\frac{143}{45}$	$\frac{160}{45}$	$\frac{190}{40}$	$\frac{60}{250}$	

On the right hand page are sketched the streams, roads, houses and property lines, and the plusses to each given.

As the topographer receives the distance from the levelman he marks them off, and standing so as to face backward on the line he sketches in the contour from the point where he last had it.

Contours, streams and auxiliary lines are all that is put on the sheets in the field, in order to save time; the rest is put on at night or on rainy days if he is so fortunate as to have any.

The chief of the party then projects his location in pencil, takes the necessary transit notes from it by which to run the line in the field, and makes a profile of the projection to see if any changes are advisable.

Then when the line is run the levelman's profile is compared with that made from the projection, and this is the test of the accuracy of the contours; if they were not correct the line would probably have to be changed.

The location is usually plotted in blue.

The topography party thus have to go over the whole location. The levelman and rodman take slopes at each station and between when necessary, noting the character of the ground, the plusses to property lines, streams, etc.

The topographer fixes up the crossings of the line by the contours, and sketches in on each side as much as possible, accuracy not being required, but merely to show up the country.

This completes the field work of the sheets; they are now inked in and a tracing made of the whole set.

This method of taking topography is used on the Rochester & Pittsburgh and on the Lehigh Valley, and was used on the South Penn. It is of special advantage on a work like the latter, where a great many parties are in the field, as the engineer in charge can put the sheets of the different parties together and so have before him the whole of the preliminary lines run up to that time, much sooner than could be done in any other way. The accuracy of the work compared with the usual way of taking slopes and plotting the contours from them, is very evident; as the place of the contour is found directly on the ground, and they are sketched in with the ground before you, so you can see exactly how and where they turn and twist.

When they are plotted from slopes, you have only your recollection of how the ground looked, when perhaps you have not seen it for several days or even weeks, and sometimes it has never been seen at all. Besides this, no matter how careful a slopeman may be, it is very doubtful whether he gets the true slope of the ground with a clinometer.

The reason the method is not used more extensively is, that it is expensive; at first sight much more so than the old way; but it amply pays for itself in the end. As in everything else the best is always the cheapest. If one-half the time and money that is often spent in running one unsatisfactory location after another, had been put in the first place upon a first-class topographical survey of the proposed route, a map would have been had upon which the best location possible could have been projected. It shows at once what can and what cannot be done. A good party in ordinary country can average from fifty to seventy-five stations a day. It is the hardest work on the corps, as eight or ten times as much ground must be covered as is gone over by the transit party, and the latter, except the axmen, have a path cut for them.

The English and Belgian railroads use the method to a certain extent, though I believe their practice is somewhat like the way a topographical survey of a town is made; that is, they divide the ground up in squares and find the elevations of points in these. This of course is a very slow and expensive way of doing the work.

B. A. CUNNINGHAM.

THE FIRELESS STEAM ENGINE.

The invention of the Fireless Locomotive, or Soda Engine, by Mr. Honigmann, which was made a few years ago, has created quite a stir among engineers and scientific men, both of Europe and this country; and well it may, for this machine utilizes every calorie that is contained in exhaust or waste steam, which has heretofore been either utterly lost by its escape up the exhaust pipe, or more or less imperfectly turned to account by being condensed by the extraction of its heat and thereby forming a vacuum.

In the latter case the heat is utilized in raising the temperature of the feed water before it enters the boiler, but really a small percentage of the heat goes towards doing this useful work, for the amount of water necessary to condense the steam is much greater than that which would be sufficient for feed water, and this extra amount of water carries off the larger part of the heat.

A general rule is that the amount of water used in condensing is 35 to 40 times the quantity of water evaporated by the boiler.

In the Soda Condenser, however, we have the notable fact that the steam is condensed by a solution whose temperature is much higher than the steam itself and no heat is carried away by any superfluous water, as in the last example.

The property possessed by the salts of Sodium, Potassium, Calcium, etc., to become heated to their boiling points by the absorption of steam, has long been known. In 1822, Faraday, in England, heated a thermometer to 212° F., by holding it in a current of steam, but when a little pulverized nitre (KNO_3) was placed on the tube he was surprised to find that the temperature rose to 234° F. He was about to publish this fact, when he learned that the same discovery had been made by Gay-Lussac, sometime before, in France. So this principle is no new thing.

The explanation of the above phenomenon is seen at once in the fact that the salt absorbed or condensed the steam, and the latent heat thus liberated went to raising the temperature of the nitre. A clear idea of the amount of heat liberated by the condensed steam can be had by taking an example:—The total heat of vaporization, or the amount of heat necessary to raise water from 0° C to a certain temperature, and then to convert it into steam is represented by the equation $W = q + \rho + A\rho u$.

Suppose steam to be produced under atmospheric pressure (760 mm.) then

q = number of calories necessary to heat the water from 0°C. to $100^{\circ} = 100.5^{\circ}$.

ρ = the heat units that are necessary to change water at 100°C. to steam, *i.e.*, to push the molecules of water apart, or to do disgregation work = 496.3 calories.

Apu = the heat units that go to overcoming the atmospheric pressure, when the steam expands, or that which does outer work = 40.2 calories. Hence,

$W = 100.5 + 496.3 + 40.2 = 637$ calories = total heat of vaporization.

When the steam is condensed, the same amount of heat that went towards changing the water at 100°C. to steam, and which is represented by $Apu + \rho = 536.5$ is liberated or changed to sensible heat, while the condensed water contains its original liquid heat, $q = 100.5^{\circ}$. This liberated heat goes to raising the temperature of the surrounding bodies. So it can be seen what a tremendous heating effect can be produced by condensing 1 kilo of steam, as shown in the last example, and also the great difference between the amount of heat that it takes to heat the water to the boiling point ($q = 100.5^{\circ}$) and that necessary to change the water at 100°C. to steam at same temperature ($\rho + Apu = 536.5^{\circ}$).

It is the greater part of this large amount of heat that is utilized by the Soda Engine, which would otherwise be thrown away.

In 1869 Mr. Spence delivered an address before the British Association at Exeter, in which a plan by which he could run an engine by making use of caustic soda, was set forth.

Loftus Perkins, in 1864, constructed a 4 H.P. engine, worked by a boiler immersed in a bath of chloride of calcium, the exhaust steam being condensed in the salt. Although this principle has long been known, and experiments on its utility have been successfully made, nevertheless, to Mr. Honigmann is due the high merit of ingeniously applying, and rendering fit for effective and really economical use this principle, which was known long before the thought of practically applying electricity had taken possession of men's minds.

Although this principle had no such barriers as were in the way of the application of Electricity, yet it has lain dormant until just now, when general attention seems to be diverted from the steam engine.

From the foregoing statements, the principle on which the Soda Engine utilizes the exhaust steam is readily seen. Let us

now turn our attention to the apparatus itself, and for an example take a stationary engine.

The steam boiler is encased in a cylindrical vessel with considerable space between the concentric shells. The steam boiler is filled with water, and the space between the outer and inner boilers is filled with the solution of soda lye.

One or both of the liquids must contain heat at starting.

This heating is done by auxiliary boilers which are also used to evaporate the soda solution when it becomes dilute.

Steam is taken from the inner boiler and led through a pipe to the cylinder of the engine; after doing the work of propelling the piston, the exhaust steam, instead of being thrown up a stack, is led at reduced pressure and temperature to the soda solution, which absorbing the steam is diluted, with simultaneous development of heat.

Not only is the latent heat of the condensed steam absorbed, but the chemical action of the condensed steam and soda lye generates additional heat, and this heat raises the temperature of the solution and passes through the partition and makes fresh steam.

The solution continues to absorb steam until it becomes quite dilute, and its boiling point has been reached, when the absorption ceases, and steam is given off from the solution itself, which creates a back pressure.

As the solution becomes dilute its boiling point is lowered. An idea of the boiling points of the solution corresponding to different degrees of dilution, can be had by examining the following table:

Soda Solution.	Boiling Point in F. Degrees.	Corresponding Pressure in lbs per sq. in. of Steam in Boiler.
NaOH + H ₂ O		
100 + 10	492.8	
" + 30	392.	225
" + 50	346.1	115.5
" + 100	291.2	45.
" + 140	266.	24.

The dilute solution is pumped through the pipe to the first auxiliary boiler where it is partially evaporated, and then passes to the second auxiliary boiler where the evaporating is completed. The reconcentrated solution then is conducted back to soda vessel.

Let us now refer to an experiment by way of illustrating still further the workings of the Soda Engine. The following is taken from the *Mining and Engineering Journal*:

The boiler of an engine was filled with 23 kilos of water at 2 atmospheres pressure and a temperature of $135^{\circ}\text{C}.$; the soda vessel with 544 kilos of soda lye, 22.9 % water, at a temperature of $200^{\circ}\text{C}.$, its boiling point being $218^{\circ}\text{C}.$ The engine overcame the frictional resistance produced by a brake. At starting, the temperature of both liquids had become nearly equal and about $153^{\circ}\text{C}.$ The temperature of the soda lye could be raised $65^{\circ}\text{C}.$ before boiling would take place, but as dilution consequent upon absorption of steam would take place, a boiling point could only be reached less than $218^{\circ}\text{C}.$, but more than $153^{\circ}\text{C}.$ The engine was then started at 100 R. P. M. Steam passing through the engine reached the solution with a temperature of $100^{\circ}\text{C}.$; the temperature of the soda lye began to rise almost immediately, but at the same time, the steam-boiler, losing steam above, and not being influenced as quickly by the increased heat below, showed a decrease of temperature. The difference of the two temperatures, which was at starting $1.3^{\circ}\text{C}.$, consequently increased to $7.2^{\circ}\text{C}.$, after 17 minutes, the boiler having then its lowest temperature, 148° .

After that both temperatures rose together, the difference between them increasing slightly to 9.5° and then decreasing continually. After 2 hours 13 minutes, when the engine had made 12,000 revolutions, the soda reached a temperature of $170.3^{\circ}\text{C}.$, which proved to be its boiling point. The steam from the engine was now blown off into the open air for the next 24 minutes.

This lowered the temperature of water and soda solution 10° and re-established its developing capacity.

The steam produced under these circumstances had a smaller pressure than before.

In this way the engine could be driven at reduced steam pressures, until resistance would become relatively too great.

The constant rise of both temperatures during the two hours, which is an undesirable feature of the experiment, was caused by a too large proportion of soda to the amount of water. Of course the more concentrated the solution, the more intense will the action of the water and soda be, and hence the greater will be the amount of heat developed.

Other experiments have shown that this quick rise is also

due to the increased resistance of the engine and consequent greater consumption of steam. By cutting off earlier and consequently using expansion, the terminal pressure and temperature of the exhaust steam will be less, and this, together with the right proportions of water and soda will prevent this objectionable rise.

After the soda lye has become so dilute that the engine no longer works, it is pumped out and conducted to the evaporating boilers. These are ordinary fixed boilers, and upon this part of the process depends the economy of the whole system.

The amount of steam or water absorbed by the soda solution when the engine is in action, has to be driven off in the evaporating boiler, before it can be used again, and the quantity of coal required to do this can be directly compared with that used in an ordinary engine boiler for the production of an equal amount of steam.

It has been found that 1 kilo of coal evaporates 5 kilos of the water from the solution, and this can be compared with the average consumption of coal in the ordinary engine, which is about 1 kilo of coal to produce 9 kilos steam.

The amount of steam evaporated by the Soda Engine, compared with that evaporated by an ordinary engine is about 37 to 42. This result would be unsatisfactory if we compared directly the relative amount of steam evaporated as shown above, but we must remember that the steam in a Soda Engine is superheated, and therefore more efficient.

The cost of the soda is small, as it does not diminish in quantity to any perceptible degree after it has been used repeatedly for months.

The advantages of the Soda Engine are numerous. The supply of steam is automatic; if a soda locomotive goes up a grade, more work is done and more steam used, but as the quantity of steam exhausted into the solution is also increased, the temperature is raised and the amount of steam generated is greater. On the other hand, in going down grade or on a level, less steam is used, and hence less heat produced by soda lye.

The engine is particularly adapted to city usage, as no smoke, steam or gas escapes, and the action of the machine is noiseless.

As said before, the steam is superheated, and hence more effective.

The heating is not more intense at one place on the boiler than

another, but is evenly distributed over the entire surface, and hence there is no danger of overheating the boiler-plates.

The fireman can also be dispensed with.

The submarine torpedo boat now lying in New York harbor is propelled by a Soda Engine. As the supply of air is limited in this craft, the combustion of fuel to produce heat would draw too heavily upon this small stock of air, and would therefore be impracticable.

Although the invention of Mr. Honigmann is but a few years old, it has reached such perfection that it is even now ready to take the place of the ordinary way of producing heat, and when it has gone through a farther process of development, it will take the place of the direct coal-burning engine, not only on account of the advantages named above, but also on account of its cheapness as compared with the direct process.

GEORGE F. PETTINOS.

ON THE EQUATION OF THE L. U. CURVE.

The equation representing the letters \mathbb{L} \mathbb{U} , which I constructed several years ago, having often been the subject of inquiry, the following explanation of the principles of its formation and of the method of its discussion is here presented.

The equation which represents the two letters in rectangular co-ordinates is

$$m n p q = 0$$

in which

$$m = \left(\frac{x+3}{5}\right)^{60} + (y+9)^{60} - 1,$$

$$n = (x-12 \pm 7)^{60} + \left(\frac{y-4}{6}\right)^{60} - 1,$$

$$p = (x+9)^{40} + \left(\frac{y}{10}\right)^{40} - 1,$$

$$q = (x-12)^2 + (y+2)^2 - \left[7 \pm \sqrt[40]{1 - \left(\frac{y+12}{10}\right)^{60}} \right]^2.$$

This equation, on discussion, will be found to give the lines forming the plain gothic letters \mathbb{L} and \mathbb{U} , the origin of co-ordinates being at the mid-height, and between the two letters.

The first point which will be noticed is that the equation is the product of four factors. These factors are given separately to simplify the discussion merely, since if multiplied together the equation formed by their product represents the same lines as before. For example, let $x^2 + y^2 - 4 = 0$ and $x + 5 = 0$ be the equations of two curves, the former of a circle and the latter of a straight line. Their product may be written,

$$(x^2 + y^2 - 4)(x + 5) = 0,$$

$$\text{or } x^3 + 5x^2 - 4x + xy^2 + 5y^2 - 20 = 0,$$

each of which represents both the circle and the line, but it is evidently easier to discuss the first than the second. So with the \sqcup equation, the curve which it represents consists of four parts—two single rectangles, one double rectangle, and one semi-annulus.

The high powers, 40 and 60, next attract attention; but instead of these particular numbers any large even number may be used. To discuss the factor p , for instance, let it be equated to zero and solved with reference to x , giving,

$$x = -9 \pm \sqrt[40]{1 - \left(\frac{y}{10}\right)^{40}}$$

and then for assumed values of y find the corresponding values of x . Each value of y gives forty values of x , but of these only two are real and belong to the curve. When y is greater than 10 the value of x is imaginary; when y is + 10, x has but the single value - 9. When $y = + 9$, there are two values of x , which differ from - 10 and - 8 only by a minute quantity, and these same values of x will be found for all values of y between + 10 and - 10. The curve, therefore, is a figure closely coinciding with a rectangle, but with corners slightly rounded, although on any usual scale the deviation from the rectangle will be scarcely discernible.

It will now be seen that each of the factors m and p represents a rectangle, and if these be properly plotted they fall together and form the letter \sqcup ; the vertical line forming the inner side of the upright part is, however, continued downward to the base. Each factor may be also solved for y , so that values of y may be found for assumed values of x in order to test the work. It will be seen

that in the factor m all real values of y lie between -8 and -10 , and all real values of x between the limits -8 and $+2$.

The factor n represents what I have called a double rectangle, viz., the two vertical parallel parts of the \mathbb{U} . Each of these parts might have been represented by a separate factor, but as they are equal and so placed that similar points have the same value of y , it is easy to combine both in one equation by introducing a \pm term in connection with the value of x . Thus each value of y gives four values of x ; for example if $y = 4$, x becomes 4, 6, 18 or 20.

The lower part of the \mathbb{U} is formed by two concentric semi-circles represented by the factor q . The discussion of this need not be dwelt upon, farther than to say that the radical in the last term is introduced both to cause two circles to appear instead of one, and to make the value of x imaginary for values of y higher than -2 . At the value $y = -2$, horizontal lines will appear in both legs of the \mathbb{U} separating the semi-annulus from the rectangles. The principle of continuity renders it impracticable, if not impossible, to avoid these lines in this method of building up the letter.

The above brief explanation will be sufficient, I think, to enable those familiar with analytical geometry to make the detailed discussion of each factor, and to plot the resulting letters. The vertical and horizontal scales should be the same, so that cross-section paper is preferable to profile paper for making the plot. Too small a scale should not be used; one which renders the height of the letters about three inches will be found advantageous.

In conclusion, I propose the following as an exercise for those interested in questions of this nature:

$$m \ n \ p = 0,$$

in which

$$m = (\frac{1}{3}x - 3)^{60} + (y - 9)^{60} - 1,$$

$$n = [y^2 + (x \pm 1)^2]^2 - 100 [y^2 - (x \pm 1)^2],$$

$$p = (x - 13)^{60} + \left(\frac{y}{10}\right)^{60} - 1.$$

It is required to discuss and plot the curve represented by this equation.

M. MERRIMAN.

REPORT OF A TRIAL OF THE STEAM HEATING
BOILERS AT LEHIGH UNIVERSITY.

By Class of 1887, Mechanical Engineering Department.

Tabulated by Lester P. Breckenridge, Instructor in Mechanical Engineering.

The steam pressures at the boilers were read from the gauges attached to each boiler.

The draft gauge consisted of a U tube partly filled with water, open to the atmosphere at one end and connected by means of a rubber tube and $\frac{3}{8}$ " pipe to the flue at the other. A sliding scale attached to the tube could be set at the water level when both ends of the tube were exposed to the air and the difference of levels read when one end was attached to the flue.

Arrangements for Weighing the Feed Water.

There are two pumps at the boiler house, one of which is used to pump water to the low pressure boilers and the other to pump water to the high pressure boilers.

A tank 30" deep and 4 feet square was placed in the room above the pumps. Two pair of scales were set on the tank and a barrel with 2" cock in the bottom provided for each scale. A line of $1\frac{1}{2}$ " pipe was run from the high pressure boiler pump to the two barrels and cocks provided so that water could be drawn into the barrels at will. The water was thus delivered to the feed tank in uniform quantities of 300 pounds. The suction pipe (2") of the low pressure boiler pump was then connected with this tank. The experiment started with the tank nearly full and ended with the water at the same place.

The coal used during the test was weighed upon scales and delivered in uniform charges of 200 pounds to the boilers.

The temperature of the feed water was taken at the high pressure pump, at the tank above and at the end boiler used during the test.

The height of the water in the boilers was read upon an arbitrary scale attached to the glass gauges and serves only to show variations in levels.

The temperature of escaping gases was obtained by immersing a chemical thermometer into a pipe ($1\frac{1}{4}$ ") filled with oil and allowed to hang in the flue connecting to chimney.

The ashes were weighed dry at the close of the trial and there were 1166 pounds. No allowance was made for unconsumed coal, as none could be seen among the ashes; fifteen buckets of

water were drawn out at the end boiler while taking the temperature at that place, being $20 \times 15 = 300$ pounds. This was deducted from the feed water. No wood was used to start the fires, but enough coal left upon the grates to start fresh fires, about 75 pounds. The same amount was left at the end of the trial to start fresh fires. The grates allowed the ashes to be dumped into the ash pit with only enough coal pulled forward on to the dead plate with which to start the fires.

After the test one of the boilers was emptied and water weighed into it until 1" showed upon the glass-gauge, and afterward for every 1 or 2 inches to the top of the glass and finally to the top of the boilers. This was done to determine the ratio between the steam and water space during the trial. Below is the result:

<i>On glass gauge.</i>	<i>Pounds in boilers.</i>
1"	4535.25
2"	4642.00
3"	4747.00
5"	4957.00
7"	5149.25
9"	5320.50
11"	5487.50
13"	5647.25
Boiler full	6865.25

The temperature of the water in boiler was 100° F.

The total number of "units" in each boiler was 912. Seventy-two of these had only one-half their surface exposed to the heated gasses, accordingly $912 - 36 = 876$ was the number of effective units in each boiler. The diameter of each unit was taken at 8" and the unit considered a sphere, this was found to check closely more careful measurements of the exact shape and surface in each unit.

The boilers tested were the 4 in center of the battery. Below is given the log of the test and the tabulated results of calculation.

Trial of 4 "Harrison Boilers" at Lehigh University by Class of 1887, Mechanical Engineering Dept., March 5, 1887.

TIME.	PRESSURES.				TEMPERATURES.					HEIGHT OF WATER IN GLASS GAUGES.				FEED WATER.		Coal Fired. Pounds.		
	Boiler No. 1. Pounds.	Boiler No. 2. Pounds.	Boiler No. 3. Pounds.	Boiler No. 4. Pounds.	Draught Gauge in Inches of Water.	Barometer in Inches of Mercury.	Feed Water at		Boiler Room	Exter- nal Air.	Escaping Gases in Flue.	No. 1 inches	No. 2 inches	No. 3 inches	No. 4 inches		Barrel No. 1. Pounds.	Barrel No. 2. Pounds.
							Pump	End Boiler										
A.M.	6	8					Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	12.3	10.	11.				
7.46																		
7.49																		
7.51			5	6												3000		
7.54																		
8.00	3	6	2	5	0.4	30.47	179	141	78	29		10.5	7.5	9.4	12.5			
8.20	7	9	9	7	.4	.47	179	144	78	25		10.2	9.5	9.3	11.4			
8.40	10	12	11	10	.4	.48	180	160	75	28	Lead	9.8	9.5	8.7	10.			
9.00	11	13	11	11	.5	.48	187	165	74	29	would	10.	8.5	8.	7.8	3000		
9.20	12	15	12	13	.4	.48	120	156	54	30	not melt	9.6	8.7	12.	10.	3000		
9.40	11	14	11	13	.4	.48	109	129	74	27		10.	7.3	9.	8.3			
10.00	11	14	11	13	.4	.48	122	119	76	27		10.2	5.75	7.5	7.5	3000		
10.20	11	14	11	13	.4	.48	168.5	122	76	29		6.	8.	8.	8.			
11.40	8	11	10	10	.4	.48	186	150	78	30	Water	8.5	9.	7.5	10.	3000		
11.00	9	12	10	10	.4	.48	185	152	78	30	boils.	11.	7.5	9.5	9.5	3000		
11.20	10	13	11	10	.4	.47	187	135	79	30		7.	7.0	9.75	7.	3000		
11.40	10	13	11	11	.4	.47	192	150	80	31		8.	9.5	8.25	8.25			
12.00	5	11	9	8	.4	.47	193	148	80	30		9.5	11.	9.5	8.	3000	6649	
P.M.																		
12.20	11	14	11	11	.4	.47	186	163	80	29		8.	6.5	9.5	6.5	3000		
12.40	13	19	11	12	.4	.46	195	170	82	30		9.	10.5	9.	8.			

1.00	9	12	11	11	.4	.46	111	145	80	30	Ther- mome- ter in oil gave 280 310 290 285 305	11.5	10.	7.5	10.	3000
1.20	9	12	11	10	.4	.45	136	130	80	30		6.5	8.	8.5	9.	3000
1.40	11	13.5	10	11	.4	.44	170	128	80	30		8.2	8.5	9.5	7.5	3000
2.00	10	13.5	11	11	.4	.42	189	125	80	30		9.5	8.	6.5	7.	3000
2.20	7.5	10	10	8	.4	.40	190	135	80	30		10.	10.5	11.5	10.	3000
2.40	8	12	10	10	.4	.40	186	164	80	29		9.5	8.5	8.	7.5	3000
3.00	10	13.5	12	11		.40	190	168	80	29		9.5	8.5	8.5	7.5	3000
3.20	11	14	11	11		.40	118	160	80	28		6.5	8.5	8.5	8.5	3000
3.40	13	14	11	12	.4	.39	123	142	80	28		6.	8.	6.	9.8	3000
4.00	12.5	14.5	11	12	.4	.38	178	140	79.5	27		7.5	9.	6.7	6.6	3000
4.20	11.5	14	11.5	12	.5	.37	102	154	79.5	26	10.	8.9	8.5	8.3	7.4	2700
4.40	9	12	10	10.5	.5	.37	190	165	80	26		8.7	8.2	6.6	9.7	1870
4.46	11	13.5	10.5									11.5	10.	11.	12.5	
4.49				9.75												
4.51																
4.54																
5.00																
Totals	263.5	345.0	280.5	286.5	10.3	822.00	4451.5	3960.0	2101.0	778	1470	230.60	229.95	231.00	228.95	26700
Averages	9.75	12.76	10.38	10.60	0.412	30.414	164.71	146.52	77.74	28.67	294	8.86	8.51	8.55	8.47	6649

*Results of the Trial of a Battery of 4 Harrison Sectional Boilers,
at Lehigh University, South Bethlehem, Pa., to Determine
the Combined Evaporative Efficiency.*

ITEMS.

1. Date of trial, March 5, 1887.

2. Duration of trial, 9 hours.

DIMENSIONS AND PROPORTIONS.—DESCRIPTION OF BOILER.

(a) Type of boiler, Sectional cast iron.

	For a single boiler.	For 4 boilers.
(b) Diameter of shell,	—	—
(c) Length of shell,	—	—
(d) Number of tubes. { Vertical,	—	—
{ Horizontal,	—	—
(e) Diameter of tubes,	—	—
(f) Length of tubes. { Vertical,	—	—
{ Horizontal,	—	—
(g) Diameter, steam drum,	—	—
(h) Length of furnace,	111"	—
(i) Width of furnace,	42"	—
(j) Kind of grate bars,	"Century."	"Century."
(k) Width of air spaces,	—	—
(l) Ratio of area of grate to area of air spaces	—	—
(m) Area of chimney,	13.64 □'	13.64 □'
(n) Height of chimney above grate,	75'	75'
(o) Length of flues connecting to chimney,	12' to 15'	12 to 15
(p) Area of flues connecti'g to chimney,	8.33 □'	8.33 □'

GOVERNING PROPORTIONS.

(a') Grate surface,	32.38 □'	129.52 □'
(b') Heating surface. { Water,	943.38 □'	3773.52 □'
{ Steam,	278.62 □'	1114.48 □'
{ Total,	1222.00 □'	4888.00 □'
(c') Area of least draught,	4.52 □'	—
(d') Ratio of grate to heating surface,0265	.0265
(e') Ratio draught area to grate,1397	.1397
(f') Ratio draught area to total heat- ing surface,0037	.0037
(g') Water space,	85.4 cu. ft.	341.6 cu. ft.
(h') Steam space,	25.2 " "	100.8 " "
(i') Ratio grate to water space,3788	.3788
(j') Ratio grate to steam space,	1.285	1.285
3. Grate surface, wide 42", long 111", 32.38 □'		
4. Water heating surface	943.38	3773.52
5. Superheating surface,	278.62	1114.48
6. Ratio of water heating surface to grate surface,	29.15	29.15

AVERAGE PRESSURES.

7. Steam pressure in boiler by Gauge,	10.8 lbs.	10.8 lbs.
8. Absolute steam pressure,	25.5 "	25.5 "
9. Atmospheric pressure per Barometer,	14.7 "	14.7 "
10. Force of draught in inches of water,	0.412 "	0.412 "

AVERAGE TEMPERATURES, FAHR.

11. Of external air,	28.69°	28.69°
12. Of Fire Room,	77.74°	77.74°
13. Of steam,	241.139°	241.139°
14. Of Escaping Gases,	294°	294°
15. Of feed water,	155.6°	155.6°

FUEL.

16. Total amount coal consumed (includes wood X 0.4),	1662.25 lbs.	6649 lbs.
17. Moisture in coal, 2%,	33.25 "	132.98 "
18. Dry coal consumed,	1629.00 "	6516.02 "
19. Total refuse dry, 1166 pounds =	17.9%	17.9%
20. Total combustible (item 18 less item 19),	1337.50	5350.02
21. Dry coal consumed per hour,	181.0	724.0
22. Combustible consumed per hour,	148.61	594.45

RESULTS OF CALOMETRIC TESTS.

23. Quality of steam (dry steam taken as unity),	—	—
24. Percentage of moisture in steam,	—	—
25. Number of degrees superheated,	—	—

WATER.

26. Total weight of water pumped into boiler and apparently evaporated,	13067.5 lbs.	52270 lbs.
27. Water actually evaporated corrected for quality of steam,	13067.5 "	52270 "
28. Equivalent water evaporated into dry steam from and at 212° F.,	13957.397 "	55829.587 "
29. Equivalent total heat derived from fuel in British thermal units,	14478.458 "	53,914,632,
30. Equivalent water evaporated into dry steam from and at 212 F. per hour,	1550.82 lbs.	6203.29 lbs.

ECONOMIC EVAPORATION.

31. Water actually evaporated per pound of dry coal from actual pressure and temperature,	8.021 lbs.	8.021 lbs.
32. Equivalent water evaporated per pound of dry coal from and at 212° F.,	8.568 "	8.568 "
33. Equivalent water evaporated per pound of combustible from and at 212° F.,	10.435 "	10.435 "

COMMERCIAL EVAPORATION.

34. Equivalent water evaporated per pound of dry coal with one-sixth refuse at 70 pounds gauge pressure from temperature of 100° F. (= item 33 \times 0.7249), . . .	7.564 lbs.	7.564 lbs.
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RATE OF COMBUSTION.

35. Dry coal actually burned per square foot of grate surface per hour, .	5.59 lbs.	5.59 lbs.
36. { Consumption of dry coal per hour, coal assumed with one-sixth refuse. } Per square foot of grate surface, .	5.47 "	5.47 "
37. { } Per sq. ft. of water heating surface, .	0.1876 "	0.1876 "
38. { } Per sq. ft. of least area for draught, .	39.45 "	39.45 "

RATE OF EVAPORATION.

39. Water evaporated from and at 212° F. per square foot of heating surface per hour, .	1.271 lbs.	1.271 lbs.
40. { Water evaporated per hour from temperature of 100° F. into steam of 70 pounds gauge pressure. } Per sq. foot of grate surface, .	41.66 "	41.66 "
41. { } Per sq. ft. of water heating surface, .	1.643 "	1.643 "
42. { } Per sq. ft. of least area for draught, .	343.1 "	343.1 "

COMMERCIAL HORSE-POWER.

43. On a basis of 30 pounds water per hour evaporated from a temperature of 100° F. into steam of 70 pounds gauge pressure, 34½ pounds from and at 212° F., .	44.95 lbs.	179.8 lbs.
44. Horse-power, Builders rating at 12 square feet per H. P. .	101.83 "	407.32 "
45. Per cent. developed below rating, .	44.1 "	44.1 "

EXPLANATION RELATING TO SOME OF ABOVE ITEMS.

Item 9.—This was read from an aneroid barometer, and was obviously incorrect. 14.7 was therefore assumed.

Item 13.—This was taken from tables corresponding to pressures under item 8.

Item 17.—A sample should have been dried, but this was overlooked and the moisture 2% was assumed. The coal had been recently put in bins and was moist to the extent assumed.

Item 28 = item 27 $\times \frac{(H - h)}{965.7}$ where H is the total number of heat units in a pound of steam at the pressure of evaporation and h the total number of heat units in one pound of the feed water corresponding to the observed temperature—or in this case

$$\text{Item 28} = 52270 \frac{(1155.45 - 123.93)}{965.7} = 55829.587$$

Item 29 = item 27 $\times (H - h)$ = item 28 $\times 965.7$
in this case item 29 = $55829.587 \times 965.7 = 53914632.17$

Item 31 = item 27 \div item 18

“ 32 = “ 28 \div “ 18

“ 33 = “ 28 \div “ 20

Items 36 to 38, First term = item 22 $\times \frac{6}{5}$

“ 40 to 42, First term = item 30 $\times .8698$ = item 30 $\times \frac{965.7}{H-h}$

Item 43 = $30 \div 34\frac{1}{2}$


Item 45 = $\frac{\text{item 43} - \text{item 44}}{\text{item 44}}$

•VISIT TO WILKES-BARRE.

On Friday, May 20, the senior civil engineers, under Prof. Merriman, made a visit of inspection to Wilkes-Barre, Pa. Their object being to examine into the methods of construction and working of the new “Separate System of Sewerage,” which has been in use in that city for the past few years. After a delightful ride over the mountains, attaining at one point an elevation of 1950 feet above sea level, the party reached the Lehigh Valley depot at 10.15, where we were met by Mr. W. V. Ingham, City Engineer, who kindly devoted the entire morning to us. He conducted the party over the city pointing out and explaining the various features of the system, with a minuteness and clearness which was highly appreciated by the class. The sys-

tem, which received its name from the fact that it is designed simply to carry off the sewage, leaving the surface drainage to be provided for by other means, is practically the same as that in use in Memphis, Tenn., Schenectady, N. Y., and a few other cities.

The advantages that are claimed for it, and justly over the old system, are: *First*—Greater economy in construction—no expensive brick conduits are necessary, terra cotta glazed pipes from 8 inches to 22 inches diameter being sufficient. *Second*—A higher degree of cleanliness due to the fact that a nearly constant volume is running through them, and at such a velocity as to prevent matter collecting on the sides of the drain, thus generating sewer gas. As a result the healthfulness of the city is materially increased; and *third*—they are so constructed as to admit of easy and rapid examination; obstructions being closely located and readily removed.

The main feature of the system as in use at Wilkes-Barre are as follows: On all streets running parallel to the river are placed 8-inch sub-mains, which connect with the street mains, 10 to 16 inches diameter, running down to the river front into a 22-inch main, which is the largest size used, and through which all the sewerage of the city finally runs to the river, at a point a mile or more below. The sub-mains are so graded that they have a summit near the middle of each block, where is located a flushing tank. These tanks, of which there are thirty or more in the city, are of the simple automatic tipping pattern, and hold 120 gallons. They can be so regulated as to tip at any interval required; from two to four times daily being found sufficient. At every hundred feet along all the sewers are placed lamp holes, through which the condition of the flow may be examined by means of a small mine lamp or a rod. And between any two of which an obstruction, should there be any, may be located. These lamp holes are constructed of a  in the sewer, the upper arm coming to within two feet of the surface, and a three-foot length of smaller diameter fitting in it and coming to the level of the pavement. By this construction the shocks of passing vehicles are not transmitted, and breakages prevented. In the several lamp and man holes examined, but a very faint trace of sewer gas was discernible. Property owners in connecting with the sewer are not compelled to put in roof-flushing pipes and ventilators, though many have them. The river frequently rises 15 or 20 feet above low

water, backing the water up in the mains more or less, but there has been no serious stoppage in the flow, which seems quite remarkable, as the city is not much over 30 feet above the river and is very level. During the three or four years since the new system has been in, only three stops due to breakages have occurred, which speaks highly for the engineer in charge.

In passing through the Court House yard the party examined with much interest the monument which marks the point whose latitude and longitude were so accurately determined by Prof. Doolittle some years since. This monument has a companion at Pottsville, both of which were put in by the Geological Survey on which to base a triangulation; but not until after the work was completed was it discovered that, owing to this location, it would be impossible to connect them.

Time did not permit in the afternoon a visit to a neighboring colliery, as had been planned, and so a short and pleasant ride down the river was indulged in. On the return trip the train was pulled by a locomotive fitted with the new "Strong" patent valve gear, which excited no little amount of interest.

Altogether the trip was a most profitable one, and it is hoped that for the benefit of the succeeding classes, these excursions will be more frequent and extended.

M. D. P.

THE LEHIGH UNIVERSITY HYDRAULIC LABORATORY.

In the eastern part of Lehigh University Park is a building 60 feet by 25 feet, divided into two rooms with a basement under the north room which has lately been fitted up with apparatus for conducting experiments in hydraulics. It is so situated that the South Mountain brook may be turned directly into it to furnish the necessary water. The quantity furnished by the brook usually varies from 10 to 15 cubic feet per minute, although after heavy rains the flow is much greater. It is first collected by a dam from which it is drawn into the building by means of an under-ground conduit provided with two sluice-gates. The conduit opens into a rectangular box called the weir-box, 19 feet long, 8 feet wide, and 3 feet deep, constructed of

2-inch plank nailed to a heavy framework and thoroughly calked, and sunk into the ground so that the top is flush with the floor of the south room. The weir-box may be filled by opening the sluice-gates, and emptied by means of a gate at the opposite end, at which end there is also placed, 2 feet 6 inches from the bottom, a metallic weir arranged so that its width can be varied from 23 inches to 5 inches. As the water rises and flows over the weir, it is conducted by an open conduit into a rectangular wooden penstock 12 feet high and base 4 feet square, situated in the basement. Gauges are placed on the side of the penstock to indicate the level of the water.

During the present term, the Senior Class in Hydraulics has performed the following experiments under the direction of Prof. Merriman :

First.—The Flow of Water over the Weirs. Each afternoon an experiment was made requiring four men and conducted in the following manner: the gates were opened allowing the water from the dam to enter the weir-box. Just as the water reached the crest of the weir, readings were taken on the hook-gauges, then the water was allowed to flow over the weir until it became constant, when, at a given signal the gate of the penstock was closed and the water flowing over the weir was held in the penstock. Readings were taken on the hook-gauges every minute and simultaneously with these, observations were taken on the penstock gauges; the experiment closed when the penstock was full, taking from 15 to 20 minutes. The quantities which enter into the weir formula, $Q = c\frac{2}{3}(2g)^{\frac{1}{2}}lh^{\frac{3}{2}}$ were then calculated from the observations taken. The coefficient of discharge c was taken from standard tables deduced by Mr. Harrison Smith from numerous reliable experiments. In determining Q , the actual quantity passed over the weir, the leakage of the penstock was measured each day. The object of the experiment was to see how nearly Q agreed with the value deduced from the second member of the equation.

Second.—The Flow of Water through Circular Orifices in thin Plates. The weir was replaced by an iron plate with a circular orifice in it and the experiment was conducted in a manner similar to the first one. The quantities were determined which enter into the formula $Q = cS\sqrt{2gh}$, S being the area of the orifice, and h the head of water above the center of the orifice. The equation was then solved for c , the coefficient of efflux.

A number of experiments were also made on the coefficient of efflux of circular orifices one inch in diameter under heads of about three feet.

The apparatus worked very well, the orifice and weir producing complete contraction, and the experiments giving satisfactory results. As each year more apparatus will probably be added, Lehigh may soon boast of a well-equipped laboratory.

E. E. SNYDER.

ADDRESS OF PRESIDENT OF ENGINEERING SOCIETY.

GENTLEMEN OF THE ENGINEERING SOCIETY:—You have conferred upon me a great honor by making me President of this Society, and according to our Constitution it is my duty now to render an account of the office which you have entrusted to me. As you well know, the Engineering Society has never been so prosperous as it has this year. This success has been largely due to the industry and energy of our officers, and especially to the efforts of our Treasurer. Our meetings have been held, with but one exception, every two weeks, have generally been well attended, and always interesting. Several times Prof. Doolittle's large recitation room has been overcrowded. Our professors and instructors have shown their appreciation of the motives of the Society by contributing interesting addresses and valuable papers. Our alumni, although having helped us greatly, could and should have done far better. These are the ones from whom we should expect the bulk of the material for our JOURNAL. Each alumnus, who is a member of the Society, should consider it his duty to contribute at least one paper every two years. Do not think by this that I take it upon myself to advise them. These words are those of one from whom the undergraduates and alumni of this University will be ever ready to take counsel, namely: our professor of Civil Engineering. In general the undergraduates cannot be expected to prepare papers which will be of much value to practical engineers. The things of most interest to engineers are those which are the result of learned observation and experiment. All these come when we get out into practical life; still, nearly every one of us who has gone into any subject with any

enthusiasm, has written, or been tempted to write, and indeed the practice is commendable and of positive value to the writer. Every engineer should be able to write in a clear and accurate manner, since nothing with greater certainty betokens one's education than his writing. In this respect the preparing of papers to be read before the Society affords the most excellent training, and every man in the Engineering Schools should make use of this great advantage more than once during the last two years of his course.

The excellency of our JOURNAL is another evidence of the good work accomplished by the Engineering Society, this year, and several of the leading Engineering publications of the United States have given us credit by reprinting during this year three of our papers. Still, I would give words of warning to those of the succeeding classes who hereafter write. Do not think that your papers will be scrutinized by only the editors and members of the Society here at the University. Remember that no matter what Engineering subject you take up, this subject will have its specialists from Lehigh University, who are subscribers of the JOURNAL. Some one lately remarked, and I think with justice, that error is the rule and truth the exception. Mistakes are easy things to make. I remember, not long ago, in one of the leading Engineering publications, there was proposed for solution a certain very interesting problem. One of our graduates, seeing the problem, and being perfectly familiar with its nature, and in need of some mental gymnastics, determined to solve it.

The problem to him was so simple that he did not give the proper care, and was led into a very grave error. This was shown in the next week's issue of the journal which proposed the problem. He afterwards expressed to me his extreme mortification at having made such a blunder in that connection. Always, if possible, take the time to check your computations. Then you feel secure; but do not be too credulous with regard to your authority.

Another suggestion with reference to the JOURNAL—and that is, accompanying the papers should be the discussion and the questions asked and answered, which are often very valuable. The Secretary can take them down, and if necessary have his memory refreshed by the principal ones in the discussion.

I would now say to the members of the class of '88 that your prospects for next year are brighter than ours were one year ago.

You now have exchanges from all the best Engineering papers in the United States and all the leading Engineering Societies, besides those to which we have easy access in the library. Next year we are promised a reading room—a place where you can go for consultation or reference.

The responsibility has now devolved upon you, and in the interest and enthusiasm with which your efforts are conducted, depends almost entirely the success of the Society at large. Arouse the talent which lies dormant in your midst. Wake up the alumni; then the professors and instructors will give you their hearty co-operation. Because a paper happens to be so technical and abstruse that you have failed to get the drift, do not be guilty of the remark that you were bored. Such is beneath your self-respect and dignity as a senior.

Finally, you have left with you on the editorial board one, who by the dispatch and interest with which he has carried out the manifold duties attending his office, has shown that he has the welfare of the Society at heart. You all know to whom I refer.

And now let me hope that you will keep up the fires and not let the pressure go down. And may the strides of progress be in keeping with those of our Alma Mater, the Lehigh University.

JOHN W. LA DOO.

THE address of the Business Manager of the JOURNAL for the ensuing year is L. R. Zollinger, P. O. Box 366, South Bethlehem, Pa.

NOW that we have reached the end of another year, it will not be out of place for us to cast a retrospective glance over the work and results of the past year in our department. The Engineering Society has never had a more successful year, and to-day it stands on a firmer basis than ever before.

The interest that has been shown in our Society is truly encouraging, and the work done during the past year has been of a quality of which we need not be ashamed.

For next year we predict and expect one of still greater success; it is our hope that the past work may prove to have been only a start, and that future classes may take it up and make of our Society one that may be known outside of our own local district for good honest work and worth. We have received material and valuable aid from our Professors, Instructors and Alumni, for which we return sincere thanks and without which we would have been sadly handicapped.

The JOURNAL is before you; and from the notices of it in other engineering papers and from those who are able to judge, we are glad to believe that it is not without some worth. We should like in this number to omit the old and monotonous request for papers from the Alumni, but cannot do it as that would destroy the symmetry of the present volume in this regard; so we hope you will bear with us and allow us to give our opinions on the subject.

We think that it would be too much for the Engineering Society to ask the Alumni, many of whom are in places distant from a library, or without opportunities for reference, to prepare studied papers. What we do request is that each Alumnus send us notes on his own practical experience, short sketches or observations on anything new in his profession—articles that would take him only a short time to prepare, but which would be of great value to us.

THE following are the officers elected by the Society for the ensuing year at the meeting held May 12:

President: George Davis.

Vice-President: H. H. McClintic.

Secretary: C. J. Parker.

Librarian: A. T. Bruegel,

Treasurer and Business Manager of the JOURNAL: L. R. Zollinger.

Editor of JOURNAL from Post Senior Class: C. C. Jones.

Editor of JOURNAL from Senior Class: J. B. Glover.

The member of the Board from the Junior Class to be elected next year.

These are all good men and will ensure success next year.

THERE is another matter of which we will venture to speak: that of obtaining a room in which to keep the Society library, exchanges, etc., and to be used as a reading room for the members.

There is no doubt that such a room, easily accessible to the members, is very much needed. The President of the Society was instructed to see the President of the University in order to find out what could be done. Our President reported at the next meeting that we would be allowed to use a room that had but a short time before been given to another Society for a similar purpose, in case they were willing.

There is not in the University at present an institution that has been of more benefit to its members, or that has done more to the credit of the University than the Engineering Society, and it is therefore strange that such a request should have been pushed off in this way by those in authority. They should see, when such a room is needed, that it is provided, and we hope that next year we will have a good room without having to make so many requests for it.

ALUMNI NOTES.

—The annual meeting of the Alumni Association will be held in Dr. Chandler's Lecture Room, Laboratory Buildings, University Campus, South Bethlehem, Pa., on Alumni Day, Wednesday, June 22, 1887, at 2 P.M.

The Alumni will lunch in the Gymnasium at 1.30 P.M., and the annual address before the Association will be delivered in the Drawing Room, Packer Hall, at 8 P.M., by Gen. Francis A. Walker, Ph.D., LL.D., President of the Massachusetts Institute of Technology, on "The Labor Problem of To-day."

1877.

—Charles R. Rauch, A.C., who has been in Colorado for some time, being very successful in his mining operations, has come East to live.

1878.

—The present address of Charles Bull, M.E., Secretary of the Alumni Association, is 103 East 16th Street, New York City.

1879.

—J. H. Paddock, M.E., is Chief Engineer of the H. C. Frick Coke Company, Scottdale, Pa. Under him are H. L. Auchmuty, C.E., '85, and J. S. Siebert, C.E., '86.

1883.

—Enos K. Bachman, E.M., died at Los Angeles, Cal, where he had gone to recruit his health, on March 17, and was buried in Nisky Hill Cemetery, Bethlehem, March 27. He was 27 years of age, and was the son of John Bachman, a soldier, killed in the late war. Mr. Bachman had been for two years an Instructor in the Department of Mining and Metallurgy and was universally liked. There were present at the funeral, of his class, Rev. W. F. More, B.A., of Catasauqua; G. S. Patterson, E.M., Jeddo; John Ruddle, M.E., Mauch Chunk; G. F. Duck, E.M., Garrett L. Hoppes, C.E., of Bethlehem; also T. M. Eynon, M.E., '81, of Philadelphia.

1884.

—H. B. Douglas, E.M., was married, on April 20, to Miss Morford, of Newtown, N. J. The ushers were J. A. Jardine, E.M., '84, and J. K. Surls, B.M., '86.

—Lewis B. Semple, B.A., is engaged in manufacturing paint at Bingen, Pa.

—Alfred S. Reeves, E.M., of Phoenixville, Pa., was married on June 8 to Miss Kate Eckert, of Reading, in Christ Cathedral; among the ushers were F. H. Purnell, E.M., '83, of Berlin, Md.; C. O. Haines, '85, of Savannah, and E. E. Stetson, '86, of Reading.

1886.

—Guadalupe de Lara, M.E., spent a few days in Bethlehem during the latter part of March to recruit his health.

—J. H. Spengler, C.E., is with the Chicago, Santa Fe & California Railroad.

—J. W. Richards, A.C., was married, on the 12th of March, to Miss Arna Gadd, of Philadelphia, by the Rev. Dr. Chapman, pastor of the Arch Street M. E. Church. Mr. Richards has accepted the position of Instructor in Mineralogy and Blowpiping in the University during Prof. Frazier's absence in Europe next year.

—W. H. Sayre, Jr., M.E., has gone to Chicago.

—F. W. Frink, C.E., is topographer for a party now located at Canadian, Larimer Co., Col.

—S. C. Hazelton, B.M., has joined the rapidly increasing party of Lehigh men at Omaha; he is Assayer in the Omaha & Grant Smelting Works.

—H. Toulmin, B.Ph., has been winning athletic honors at the University of Pennsylvania, where he is taking a course in Medicine.

—W. A. Lydon, B.M., expects to take the degree of E.M., this year.

1887.

—J. M. Howard, having obtained a position on the Pennsylvania Railroad, at Harrisburg, has finished his work and left college.

—B. A. Cunningham, an Editor of the JOURNAL, has also finished his work, having accepted a position with the Lehigh Valley Railroad.

DONATIONS TO THE LIBRARY OF THE SOCIETY.

—"Civil Engineers' Handbook" and the "Field Practice of Laying Out Circular Curves for Railroads," by John C. Trautwine, C.E. From John C. Trautwine, Jr., C.E.

—"Illustrations and Descriptions of Recent Locomotives" (1886). From W. H. Boardman of *The Railroad Gazette*.

—"Report of the Secretary of Internal Affairs of Pennsylvania." From Prof. Mansfield Merriman.

—Journals received by the Society: *The Engineering News*, *The Engineering and Mining Journal*, *The American Engineer*, *The Journal of the Association of Engineering Societies*, *The Railroad Gazette*, *The Iron Age*, Annual Report of Ohio Society of Surveyors and Civil Engineers (1886), Annual Reports of Illinois Society of Engineers and Surveyors for 1886 and 1887, *Stevens Indicator*, Selected Papers of the Civil Engineers' Club of the University of Illinois (1886-87), and Proceedings of the Missouri Association of Civil Engineers and Surveyors, (1886).

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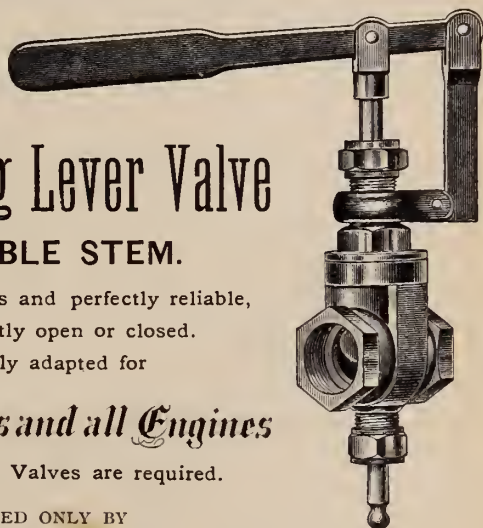
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